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date

METHOD FOR IDENTIFICATION OF A USER'S UNIQUE IDENTIFIER  
WITHOUT STORING THE IDENTIFIER AT THE IDENTIFICATION SITE

Field of the Invention

This invention relates to identity authentication  
in a communications system or network context, and more  
particularly to the use of a method involving hashing to  
5 allow identification of users without requiring storage of  
the user's unique identifier at the identification site.

Background of the Invention

Some current arrangements for verification of user  
identity in a communication system are susceptible to  
10 compromise in the event of hacking. For example, if a user  
makes a purchase from an on-line retailer, the user's name  
and password, or possibly his credit card number or other  
important data, is stored by the retailer at the retailer's  
computer or server. It is a fact that such online computers  
15 or servers may be penetrated by hackers or malfeasors. Once  
penetrated, the user's name and password, credit-card number  
or other data may be accessed by the hacker, and possibly  
misused. Firewalls are used with computers and servers in  
an attempt to avoid having a server penetrated. However,  
20 firewalls are not perfect, and it is not clear that  
conventional methods for protecting such data are effective.  
The only way to be sure that important information is not

December 3, 2001

compromised is to avoid placing it on a server connected to a communications system.

In general, cryptography does not solve the problem of penetration of the user's server or computer, although it may be useful for protection of the data while it is in transit. Even for that use, however, public-key cryptography may not be as useful as it seems, as it tends to be somewhat difficult to use, because both the public and private keys tend to be very large numbers which cannot be remembered by the users, and therefore require storage on a separate module such as a floppy disk. Thus, existing protections against loss of identity information to a successful hacker may not be as effective as it might be.

Additional protection is desired for information stored on a communications server or computer.

#### Summary of the Invention

A method according to an aspect of the invention provides for identification between or among at least first and second users communicating by means of a communication system or network. The method includes the step of providing a first unique identifier from the first user to the second user. This unique identifier may be a user name and password, or it may be any alphanumeric which the first user selects or adopts. At least the first and second users enter into an agreement as to a plurality of hash or hashing salts. In one embodiment of the invention, the agreement provides for five hash salts. There need not be an explicit agreement on the hash salts, as software which each of the parties uses to implement the invention may be preprogrammed with specific salts, or with some way to reach agreement. However determined, at least five salts are agreed to

December 3, 2001

between or among the parties, as well as the type or types of hash operations to be used. At the second user, a hash operation is performed on one of (a) the first unique identifier and (b) an agreed-upon deterministic transformation of the first unique identifier, using the first (A) salt from the plurality of salts which was agreed to, to thereby produce a first (A) data hash. Data hashing is a well-known technique, and any conventional hashing technique can be used. In this context, a deterministic transformation includes a defined subset of the unique identifier, or the result of application of the unique identifier to some defined equation; ultimately, the only requirement is that each of the first and second users must be able to perform the same operation to reach the same result. At the second user, a hash operation is performed on the unique identifier, or its transformation, using the fifth (E) of the hash salts, to thereby produce a fifth (E) data hash. At the second user, a hash operation is performed on at least a portion of the first (A) data hash using the second (B) of the plurality of hash salts, to thereby produce a second (B) data hash. The second user proceeds to perform a hash operation on at least a portion of the first (A) data hash, using the third (C) of the plurality of hash salts, to thereby produce a third (C) data hash. At the second user, a hash operation is performed on at least a portion of the third (C) data hash using the fourth (D) of the plurality of hash salts, to thereby produce a fourth (D) data hash. At the second user, the third (C) data hash is discarded. Data hashes B and D are stored in memory at the second user's location or site, at addresses pointed to by hash E. At this point in the

December 3, 2001

operation, the second user has in its memory data hashes B and D, but hash E is not explicitly stored. The second user may also store the various salts, and the types of hashing operations. Ideally, the second user also discards the  
5 unique identifier (UI). This completes the initial authentication process, where, or in which, the first user identifies himself to the second user, so that the second user can later recognize the first user at the later actual log-in to the second user. The later log-in includes, at  
10 the first user, performing a hash operation, using the fifth one (E) of the plurality of hash salts, on at least a portion of one of (a) the first unique identifier and (b) data deterministically derived from the unique identifier, to thereby produce (a replica of) the fifth (E) data hash;  
15 this step may be performed as part of the initial authentication or as part of each log-in. To start the first log-in, the first user keys in his unique identifier, which as mentioned may be a user name and password. The first user uses salt E to perform a hash operation on the  
20 unique identifier or its derivative (if not already performed), to thereby produce data hash E. Data hash E is transmitted to the second user. It should be noted that it is not possible to determine the unique identifier from only hash salt E and data hash E. The second user, when it  
25 receives data hash E, acts on it as initiating a log-in. and accesses its memory at the locations specified by data hash C, to recover data hashes B and D, which are associated with the first user. The second user then generates a random number, and encrypts the random number in any conventional  
30 way with a key deterministically derived from data hash B. The encrypted random number is sent over the communication

December 3, 2001

path or network to challenge the first user. The first user then proves that he is in possession of data hash B by decrypting the encrypted random number using its own copy (or reconstruction) of hash B, to thereby form an extracted random number. Having the random number, then, proves that the user attempting to log on has data hash B, which only the original entity (user A) which authenticated itself can have. Data hash C is transmitted from the first user to the second user together with the extracted random number for authentication of data hash C. The second user compares the original random number with the returned random number, and deems the transmission authentic if they match. At this point, the second user once again has possession of data hash C, as well as data hashes B and D. The second user then performs a hash operation on the third (C) data hash using the fourth (D) hash salt, which generates a sixth (F) data hash, which should be equal or identical to the fourth (D) data hash if all goes well. Naturally, if there is any deviation among the various numbers, the third (C) and sixth (F) data hashes will not be the same as during the initial authentication. The second user then compares the fourth (D) and sixth (F) data hashes, to determine if they are equal. If they are equal, the second user deems the message to be from the first user, and enables the connection or communication between the users in any conventional manner. The second user then discards the third (C) data hash, so that it cannot be compromised.

In one variant of the method of the invention, after the steps at said second user of (a) performing a hash operation on one of (a) the first unique identifier (UI) and (b) an agreed-upon deterministic transformation of the first

December 3, 2001

unique identifier, using the first (A) salt, to thereby produce a first (A) data hash and (b) performing a hash operation on the unique identifier, or its transformation, using the fifth (E) of the hash salts, to thereby produce a fifth (E) data hash, a further step of discarding the first unique identifier is performed at the second user.

#### Brief Description of the Drawing

FIGURE 1 is a simplified block diagram of a network with plural users, where the plurality is two;

FIGURE 2a is a simplified diagram illustrating the steps taken at the first and second of the users of FIGURE 1 to perform an initial authentication of the first user to the second user, and FIGURE 2b is a simplified diagram illustrating the steps taken at the first and second users of FIGURE 1 to log the first user onto the second user after the initial authentication.

#### Description of the Invention

FIGURE 1 is a simplified block diagram of a system including a first user's computer or server 12, which communicates with a second user's computer or server 14 by way of a communication or transmission path 16, which in this case includes the Internet 18. If the first user 12 is a purchaser, and user 14 is a retailer, some information relating to the first user 12 must be stored at the second user's location 14. For example, such information might be a user name and password, or it might be some other private data (any of which is termed a "unique identifier" herein).

If a hacker can penetrate the second user's computer 14, he may undesirably be able to access the private data and cause mischief, such as assumption of the first user's identity to the second user, in this example the retailer. Typically,

December 3, 2001

the retailer will store the user name and password in the server, and compare the user name and password of someone accessing his site with the stored name and password. This is ordinarily done by using the user's name as a pointer to a memory, in which the password is stored. If the proffered user name points to a memory location at which a password is stored which is the same as the proffered password, the user is deemed to be verified. If the hacker were able to obtain the user name and password from the second user's site, it would then be possible for the hacker to contact the retailer's computer 14 using that user name and password, and pass himself off as the user of computer 12. It will be recognized that the first and second users can have any relationship, and are not limited to purchaser and retailer.

According to an aspect of the invention, the user's name and password, or his other unique identifier (UI), is processed by hashing the unique identifier, and by storing only some of the resulting hashed data. Hashing is well known in the art, and many algorithms are available, any of which can be used, including Sha and MD5. In a particular embodiment of the invention, the selected hashing was MD5.

FIGURE 2a represents the processing performed by the first and second users 12 and 14 of FIGURE 1 in an initial authentication process. In FIGURE 2a, those steps performed at the first user are on the left, and those performed at the second user are at the right. In one application of the invention, this corresponds to an initial log-on or log-in process. More particularly, according to an aspect of the invention, the first user 12 generates and transmits to the second user 14 his user name and password,

December 3, 2001

or any other unique identifier (UI), as suggested by block 210 of FIGURE 2a and by transmission path 211. In addition, the first and second users 12, 14 must agree on a deterministic transformation of the unique identifier. This transformation may be no transformation at all, or it may be some selected portion, such as the first N bits, or every other tenth bit, or the like. Alternatively, it may be a one-to-one word transformation. In addition to the agreement on the deterministic transformation, agreement must be reached on the identities of five hash salts, which may be designated as A, B, C, D, and E. These are strings of numbers on which the parties agree. The agreement may be reached automatically, as by inclusion of the information in the software which implements the invention for the users. As an alternative, of course, the agreement could be reached in some other way, as by telephone communication between the parties. However accomplished, the unique identifier is transmitted from the first user 12 to the second user 14, and the second user 14 then has available not only the unique identifier, but also has the five hash salts, and knows the hash technique(s) to be used and the appropriate transformation of the unique identifier.

Once the unique identifier (UI) has been transmitted to the second user 14 as suggested by path 211 of FIGURE 2a, the second user 14 begins to operate on the information. If a deterministic transformation of the unique identifier has been agreed to, that transformation is done first, as suggested by block 214 of FIGURE 2a. Block 232 represents the performing of a hash operation on the unique identifier (UI), using agreed-upon salt E, to produce data hash E. The second user then, in block 212, performs a



December 3, 2001

hash operation on the unique identifier (or its deterministic transformation, as appropriate), using the first hash salt (salt A) which was agreed to, to thereby produce a first data hash, which may be termed "data hash A." Once data hashes A and E have been generated, the logic or method flows from block 212 by way of logic path 218 to a block 220. Block 220 represents the discarding of the unique identifier (UI), so that the UI resides for the least possible time in the second user's processor (14 of FIGURE 1) and is therefore less available to be hacked. The next block of FIGURE 2a, namely block 222, represents the performing of a hash operation on data hash A, using the second agreed-to salt, designated "salt B," to thereby produce another data hash, designated "data hash B." Block 224 of FIGURE 2a represents the performing of a further hash operation on data hash B using the third agreed-upon salt, designated "salt C," to thereby generate a data hash designated "C." At this point in the calculations, there is no longer any need for data hash A, and it can be discarded, as represented by block 226.

Block 228 of FIGURE 2a represents the performing, by the second user 14, of a hash operation on data hash C using agreed-upon salt D. This results in a hash designated as "data hash D". Following this step, block 230 represents the discarding of data hash C. Block 234 of FIGURE 2a represents the saving in memory of data hashes B and D at addresses controlled or established by data hash E (or some derivative of data hash E). If the salts A through E are not specified by the software, the salts may also be stored in memory. Following this step, data hash E may be discarded, as suggested by block 235. This completes the

December 3, 2001

initial authorization portion of the process.

FIGURE 2b represents the "other" half of the authentication process, corresponding, in one application of the invention, to a later log-in by the first user 12 to second user 14. In FIGURE 2b, the second user 12 generates his unique identifier (UI), as for example by having the user type it onto the keyboard of his computer, as suggested by block 240. The software associated with or implementing the processing according to an aspect of the invention then performs block 242, which represents the performing of a hash on the unique identifier using salt E, which results in generation of data hash E. Assuming that the unique identifier was the same as the one originally produced, data hash E should be identical to that previously generated by second user 14 at the initial set-up. As noted above, data hash E was never explicitly stored by second user 14, but was instead implicit in the memory addresses selected for storing data hashes B and D during the operations associated with FIGURE 1a. Data hash E is transmitted from first user 12 to second user 14, as suggested by path 244 of FIGURE 2a, whereupon the second user 14 has an explicit version of data hash E. Block 246 represents the addressing of memory with data hash E (or something derived therefrom) at the second user 14, to access data hashes B and D. If the unique identifier entered in block 240 was correct, the memory should return the same data hashes B and D that were initially stored therein. Block 248 represents the generation at the second user 14 of a random number with which first user 12 will be "challenged." The random number is encrypted in block 250 with an encryption key derived from hash B. The purpose of the encryption is not

December 3, 2001

necessarily to protect the random number from interception on its way back to first user 12, but is instead to find out if the person or user currently trying to access second user 14 is in possession of the hash B, to thereby at least partially authenticate the first user A. The encrypted random number is transmitted to the first user 12, as suggested by path 252.

In order to continue with the process of FIGURE 2b, certain hashes are required at first user 12. These hashes can be generated by user 1 during the initial authorization described in conjunction with FIGURE 2a, or they may be performed by the first user 12 during the processes described in conjunction with FIGURE 2b. In any event, the generation of the various hashes B and C at first user 12 in FIGURE 2b follows steps corresponding to at least blocks 212, 222, and 224 of FIGURE 2a.

At the first user 12, the encrypted random number received from second user 14 is decrypted with data hash B, to recover the random number, as suggested by block 254 of FIGURE 2a. The random number is transmitted in unencrypted form from the first user 12 back to the second user 14, together with data hash C. The purpose of sending data hash C together with the random number is to authenticate the data hash C which is being transmitted, since only the authentic first user 12 would have data hash B, and so only the authentic user could decrypt the random number. Thus, data hash C is transmitted to second user 14 together with the decrypted random number, as suggested by path 258 of FIGURE 2b.

When the decrypted random number is received at the second user 14 together with data hash C, the second

December 3, 2001

user 14 verifies the random number, as suggested by block 260 of FIGURE 2b, by comparison with the random number originally sent. Assuming that the random number is authenticated, the data hash C is deemed to be authentic, and the logon process proceeds to block 262. Block 262 represents the performing of a hash operation on data hash C using salt D. Since these are presumably the same as those associated with block 228 of FIGURE 2a, they result in a data hash F, which should be identical to data hash D.

Block 264 represents the comparison of data hashes D and F.

If they are the same, first user 12 is deemed to be the same party that initially was set up or authenticated, as suggested by block 266. The channel is then maintained open, or other suitable action is taken consistent with log-in authentication of the first user. Failure of the process at any step results in a "not authenticated" result.

Ideally, the authentication process would be performed over a secure channel, such as a secure tunnel or virtual private network (VPN) in the context of an Internet connection, but this is not necessary to the invention.

The salient advantage of the described system is that, even if the second user's computer or server containing data hashes B and D is compromised, the hacker has not obtained sufficient information to impersonate first user 12. In particular, the hacker does not have the unique identifier, which is needed in order to generate data hash C. In order to authenticate himself to second user 14, a putative user must have data hashes B, C, and E. The putative user must have data hash B in order to decrypt the random number. He must also supply data hash C to the second user 14. Unauthorized access to the computer or

December 3, 2001

server of second user 14 can provide only data hashes B and D, and that only if he already has data hash E. Data hash E is mandatory for accessing data hashes B and D in second user 14's server, and so a hacker, even gaining access to the second user's server, cannot determine any one of data hashes A (which is not stored), B (stored in memory but not identifiable), C (which is not stored), D (stored in memory but not identifiable), or E (which is not explicitly stored). Thus, in principle, unauthorized access to the second user's server cannot enable a hacker to impersonate first user 12.

Other embodiments of the invention will be apparent to those skilled in the art. For example, different hashing operations may be used during the course of a single authentication or log-in, and agreement on the type of hashing operation, and when it is used, must also be agreed upon and stored by both or all parties, or inherent in the software. The processes of the invention may be performed in software, hardware or firmware. Processing may be in digital serial or parallel form. While the network illustrated and described in FIGURE 1 is the Internet, other networks may be used, such as a local area network (LAN).

Thus, a method according to an aspect of the invention provides for identification between or among at least first (12) and second (14) users communicating by means of a communication system (16) or network. The method includes the step (210, 211) of providing a first unique identifier from the first user (12) to the second user (14).

This unique identifier may be a user name and password, or it may be any alphanumeric which the first user (12) selects

December 3, 2001

or adopts. At least the first and second users (12, 14) enter into an agreement as to a plurality of hash or hashing salts. In one embodiment of the invention, the agreement provides for five hash salts (salts A, B, C, D, and E).

5 There need not be an explicit agreement on the hash salts, as software which each of the parties uses to implement the invention may be preprogrammed with specific salts, or with some way to reach agreement. However determined, at least five salts are agreed to between or among the parties, as  
10 well as the type or types of hash operations to be used. At the second (14) user, a hash operation (212) is performed on one of (a) the first unique identifier (UI) and (b) an agreed-upon deterministic transformation of the first unique identifier (214), using the first (A) salt from the  
15 plurality of salts which was agreed to, to thereby produce a first (A) data hash. Data hashing is a well-known technique, and any conventional hashing technique can be used. In this context, a deterministic transformation includes a defined subset of the unique identifier, or the  
20 result of application of the unique identifier to some defined equation; ultimately, the only requirement is that each of the first and second users must be able to perform the same operation to reach the same result. At the second user (14), a hash operation (232) is performed on the unique  
25 identifier, or its transformation, using the fifth (E) of the hash salts, to thereby produce a fifth (E) data hash. At the second user (14), a hash operation (222) is performed on at least a portion of the first (A) data hash using the second (B) of the plurality of hash salts, to thereby  
30 produce a second (B) data hash. The second user (14) proceeds to perform a hash operation (224) on at least a

portion of the first (A) data hash, using the third (C) of the plurality of hash salts, to thereby produce a third (C) data hash. At the second user (14), a hash operation (228) is performed on at least a portion of the third (C) data hash using the fourth (D) of the plurality of hash salts, to thereby produce a fourth (D) data hash. At the second user (14), the third (C) data hash is discarded (230). Data hashes B and D are stored (234) in memory at the second user (14)'s location or site, at addresses pointed to by hash E.

At this point in the operation, the second user (14) has in its memory data hashes B and D, but hash E is not explicitly stored. The second user may also store the various salts, and the types of hashing operations. Ideally, the second user also discards (220) the unique identifier (UI). This completes the initial authentication process, where (in which) the first user (12) identifies himself to the second user (14), so that the second user (14) can later recognize the first user (12) at the later actual log-in to the second user (14). The later log-in includes, at the first user (12), performing a hash operation (242), using the fifth one (E) of the plurality of hash salts, on at least a portion of one of (a) the first unique identifier and (b) data deterministically derived from the unique identifier, to thereby produce (a replica of) the fifth (E) data hash; this step may be performed as part of the initial authentication or as part of each log-in. To start the first log-in, the first user (12) keys in his unique identifier, which as mentioned may be a user name and password. The first user (12) uses salt E to perform a hash operation on the unique identifier or its derivative (if not already performed), to thereby produce data hash E. Data hash E is transmitted

December 3, 2001

(244) to the second user (14). It should be noted that it is not possible to determine the unique identifier from only hash salt E and data hash E. The second user (14), when it receives data hash E, acts on it as initiating a log-in. and  
5 accesses its memory (246) at the locations specified by data hash C, to recover data hashes B and D, which are associated with the first user (12). The second user (14) then generates (248) a random number, and encrypts (250) the random number in any conventional way with a key  
10 deterministically derived from data hash B. The encrypted random number is sent over the communication path or network (252) to challenge the first user (12). The first user (12) then proves that he is in possession of data hash B by decrypting the encrypted random number (254) using its own  
15 copy (or reconstruction) of hash B, to thereby form an extracted random number. Having the random number, then, proves that the user attempting to log on has data hash B, which only the original entity (user A) which authenticated itself can have. Data hash C is transmitted (256) from the  
20 first user (12) to the second user (14) (by way of path 258) together with the extracted random number for authentication of data hash C (258). The second user (14) compares the original random number with the returned random number (260), and deems the transmission authentic if they match.  
25 At this point, the second user (14) once again has possession of data hash C, as well as data hashes B and D. The second user (14) then performs a hash operation (262) on the third (C) data hash using the fourth (D) hash salt, which generates a sixth (F) data hash, which should be equal  
30 or identical to the fourth (D) data hash if all goes well. Naturally, if there is any deviation among the various



December 3, 2001

numbers, the third (C) and sixth (F) data hashes will not be the same as during the initial authentication. The second user (14) then compares (264) the fourth (D) and sixth (F) data hashes, to determine if they are equal. If they are equal, the second user (14) deems the message (266) to be from the first user (12), and enables the connection or communication between the users (12, 14) in any conventional manner. The second user (14) then discards the third (C) data hash, so that it cannot be compromised.

In one variant of the method of the invention, after the steps at said second user (14) of (a) performing a hash operation (212) on one of (a) the first unique identifier (UI) and (b) an agreed-upon deterministic transformation of the first unique identifier (214), using the first (A) salt, to thereby produce a first (A) data hash and (b) performing a hash operation (232) on the unique identifier, or its transformation, using the fifth (E) of the hash salts, to thereby produce a fifth (E) data hash, a further step (220) of discarding the first unique identifier is performed at the second user (14).